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~~DESCRIPTION~~

OPTICAL MODULATION ELEMENT AND PROJECTION DISPLAY DEVICE

Background Of The Invention

~~Technical Field~~

1. Field of the Invention

The present invention relates to an optical modulation element and a projection display device, and more particularly, to a layout structure of optical elements on the periphery of an optical modulation element that modulates a light flux according to image information.

2. Description of Related Art

~~Background Art~~

A projection display device basically includes a light source lamp unit, an optical unit for optically processing a light flux emitted from the light source lamp unit so as to synthesize a color image according to image information, a projection lens unit for magnifying and projecting the synthesized light flux onto a screen, a power supply unit, and a circuit substrate on which a control circuit and the like are mounted.

Figs. 11(A)-(C) schematically show ~~FIG. 11 schematically shows~~ the construction of the optical unit and the projection lens unit of the above-mentioned components. As shown in this figure, an optical system of an optical unit 9a includes a lamp body 81 serving as a light source, a color separation optical system 924 for separating a light flux W emitted from the lamp body 81 into

color light fluxes R, G, and B of the primary colors, red (R), green (G), and blue (B), three liquid crystal modulation elements (optical modulation elements) 925R, 925G, and 925B for modulating each of the separated color light fluxes according to image information, and a color synthesizing prism 910 in the shape of a prism with a square cross section to synthesize the modulated color light fluxes. The light flux W emitted from the lamp body 81 is separated into each of color light fluxes R, G, and B by the color separation optical system 924 having various types of dichroic mirrors. The red and green light fluxes R and G of each of the color light fluxes are emitted from outgoing sections formed in the color separation optical system 924 toward the corresponding liquid crystal modulation elements 925R and 925G. The blue light flux B is guided to the corresponding liquid crystal modulation element 925B via a light guide system 927. The blue light flux B is emitted from an outgoing section formed in the light guide system 927 toward the corresponding liquid crystal modulation element 925B.

As shown in FIGS. 11(B) and 11(C) as enlarged views, in the optical unit 9a, polarizers 960R, 960G, and 960B are respectively placed on the incident sides of the liquid crystal modulation elements 925R, 925G, and 925B so that they unify the planes of polarization of the respective

color light fluxes to be incident on the liquid crystal modulation elements 925R, 925G, and 925B. Moreover, polarizers 961R, 961G, and 961B are respectively placed on the outgoing sides of the liquid crystal modulation elements 925R, 925G, and 925B so that they unify the planes of polarization of the respective modulated color light fluxes to be incident on the color synthesizing prism 910. The actions of these polarizers permit the projection of a high-contrast magnified image onto a screen 10. The outgoing-side polarizers 961R, 961G, and 961B of the two types of polarizers that sandwich the liquid crystal modulation elements 925R, 925G, and 925B, respectively, are bonded to the light outgoing surfaces of the liquid crystal modulation elements 925R, 925G, and 925B.

As the liquid crystal modulation elements 925R, 925G, and 925B, an active-matrix liquid crystal device is generally used, in which pixels arranged in a matrix are controlled by a switching element.

In order to enhance the contrast of an image to be magnified and projected onto the screen 10, it is effective to bond a polarizer, which has a high wavelength selectivity with respect to polarized light, to the light outgoing surfaces of each of the liquid crystal modulation elements 925R, 925G, and 925B. However, such a polarizer having a high wavelength selectivity absorbs much light, and

therefore, generates much heat. Inside the projection display device mentioned above, air flow is formed as shown in FIG. 11(C) and cools the polarizer. Since the polarizer is directly attached to the light outgoing surfaces of the liquid crystal modulation element, however, heat is apt to be transmitted to the liquid crystal modulation element, and to thereby increase the temperature of the liquid crystal modulation element. This increase in temperature deteriorates the optical properties of a liquid crystal panel and the image contrast.

Accordingly, it may be possible to place the polarizer apart from the light outgoing surfaces of the liquid crystal modulation element. However, if the polarizer is simply placed apart from the light outgoing surfaces, there is a fear that the switching element in the liquid crystal modulation element may malfunction due to a light flux reflected by the light outgoing surfaces of the liquid crystal modulation element. Moreover, there is a fear that dust or the like may be caused by an air flow formed inside the projection display device to adhere to the light outgoing surfaces of the liquid crystal modulation element, and it may make high-quality image projection impossible.

4 Summary Of The Invention

In view of the above-mentioned problems, an object of the present invention is to provide an optical modulation element and a projection display device that achieve high-

quality image projection by preventing dust from adhering to the light outgoing surfaces of the optical modulation element without deteriorating the switching characteristic of the optical modulation element.

~~Disclosure of Invention~~

In order to achieve the above object, an optical modulation element of the present invention has a transparent plate on at least one surface thereof.

In such an optical modulation element, heat generated by a polarizer can be prevented from being directly transmitted thereto, and the increase in temperature thereof can be controlled. This makes it possible to prevent the optical properties of the optical modulation element from deteriorating due to the heat generation of the polarizer.

Furthermore, the transparent plate can prevent light reflection at the interface surface between the optical modulation element and air because of the difference in refractive index therebetween. This makes it possible to prevent the optical properties of the optical modulation element from deteriorating due to surface reflection.

Still furthermore, even if dust or the like is diffused by the air flow formed inside a projection display device, since the surface of the optical modulation element is protected by the transparent plate, direct adhesion of dust

thereto can be prevented.

Preferably, a polarizer is bonded to the transparent plate of the optical modulation element. Since this can prevent the entry of dust between the optical modulation element and the polarizer, the polarization condition of light is not disturbed by dust. When a black image is displayed, a spot on the black image corresponding to a portion where dust adheres can be prevented from being displayed as a white blank, which improves the display quality.

The surface of the transparent plate of the optical modulation element may be coated with a surface active agent or treated for electrostatic protection. In this case, since it is difficult for dust to adhere to the surface of the transparent plate, the adhesion of dust can be avoided more effectively.

A projection display device of the present invention includes an optical modulation element for modulating a light flux emitted from a light source according to image information, and projection means for magnifying and projecting the light flux modulated by the optical modulation element onto a projection plane, wherein a light outgoing surfaces of the optical modulation element is provided with a transparent plate.

In the projection display device of the present

invention, a polarizer is not directly attached to the light outgoing surfaces of the optical modulation element, and a transparent plate is formed thereon. Therefore, it is possible to prevent heat generated by the polarizer from being directly transmitted to the optical modulation element, and to control the increase in temperature of the optical modulation element. This can avoid the deterioration of the optical properties of a liquid crystal panel resulting from the heat generation of the polarizer.

Furthermore, the transparent plate formed on the light outgoing surfaces of the optical modulation element can prevent light reflection at the interface surface between the light outgoing surfaces of the optical modulation element and air because of the difference in refractive index therebetween. This prevents the deterioration of the switching characteristic of the optical modulation element resulting from the reflection at the light outgoing surfaces of the optical modulation element.

Still furthermore, even if dust or the like is diffused by the air flow formed in the device, since the light outgoing surfaces of the optical modulation element is protected by the transparent plate, it is possible to prevent dust from directly adhering to the light outgoing surfaces. Consequently, according to the projection display device of the present invention, a high-quality image can be

projected onto a projection plane by preventing dust from adhering to the light outgoing surfaces of the optical modulation element without deteriorating the switching characteristic of the optical modulation element.

Preferably, at least one surface of the transparent plate is coated with an antireflection film. The use of such a transparent plate makes it possible to eliminate the light reflected by the transparent plate and returned to the optical modulation element, and to prevent the deterioration of the switching characteristic of the optical modulation element due to the return light from the transparent plate.

Preferably, the thickness of the transparent plate is set larger than the focal depth of the projection means. When the thickness is set thus, even if dust or the like adheres to the surface of the transparent plate, it is blurred and made inconspicuous on the projection plane.

When a polarizer is interposed between the transparent plate and the projection means, preferably the transparent plate is made of a drawing resin and the optical axes of the transparent plate and the polarizer are aligned with each other. This makes it possible to prevent image degradation resulting from the anisotropy of the liquid crystal modulation element.

The transparent plate may be made of the same material as that of a pair of substrates which sandwich a polarizing

layer, of the constituents of the polarizer. By thus making the transparent plate of the same material as that of the substrates for sandwiching the polarizing layer, the number of types of components can be reduced. Furthermore, since the substrates for sandwiching the polarizing layer are considerably faultless substrates to be bonded to the optical modulation element, when the transparent plate is made of the same material as that of the substrates, image degradation resulting from a defect in the transparent plate can be naturally avoided.

When the polarizer is bonded to the transparent plate, since it is possible to prevent dust from entering between the optical modulation element and the polarizer, the polarization condition of light is not disturbed by dust. Moreover, when a black image is displayed, a spot on the black image corresponding to a portion where dust adheres can be prevented from being displayed as a white blank, which improves the display quality.

The surface of the transparent plate may be coated with a surface active agent or treated for electrostatic protection. In this case, since it is difficult for dust to adhere to the surface of the transparent plate, the adhesion of dust can be avoided more effectively.

The optical modulation element may be attached via a mounting member to a color synthesizing prism for forming

the projection means. The mounting member includes a mounting frame plate composed of first and second frame members for sandwiching the optical modulation element, a fixed frame plate to be in fixed contact with the light incident surface of the color synthesizing prism, and an intermediate frame plate to be sandwiched between the mounting frame plate and the fixed frame plate.

Then, the mounting member with the optical modulation element mounted thereon is attached by making the fixed frame plate abut on the color synthesizing prism. Therefore, the optical modulation element can be held by the mounting member, and the mounting is facilitated.

When the mounting frame plate is made of a resin containing glass fiber, it is possible to restrict linear expansion, to prevent shifting of the liquid crystal modulation element, and to maintain a constant temperature and a uniform in-plane temperature distribution of the liquid crystal modulation element.

On the other hand, when the mounting frame plate is made of metal, it is possible to improve the heat radiation effect. In particular, when a polarizer is bonded to the transparent plate, it is preferable that the mounting frame plate be made of metal because heat arises with the absorption of light by the polarizer.

A projection display device of the present invention

includes an optical modulation element for modulating a light flux emitted from a light source according to image information, and projection means for magnifying and projecting the light flux modulated by the optical modulation element onto a projection plane, the projection display device further including a partition for surrounding the optical modulation element via air and separating the optical modulation element from the light source and the projection means, the partition having a transparent plate fitted in a light incident window corresponding to a light incident surface of the optical modulation element, and a light outgoing window for emitting the light flux modulated by the optical modulation element therefrom.

In the projection display device having this construction, by placing a polarizer on the outer wall of the partition or apart from the partition, most of the heat generated by the polarizer can be removed outside the partition. Moreover, since the optical modulation element is surrounded by the partition, it is possible to prevent dust from entering from outside and adhering to the light incident and outgoing surfaces of the optical modulation element, and to thereby continuously project a high-quality image onto the projection plane.

In the projection display device having this construction, the dissipation of heat from the optical

modulation element itself can be promoted by placing a fan for circulating air inside the partition, which can avoid the deterioration of the optical properties resulting from the heat generation by the optical modulation element.

In such a projection display device, when a polarizer is bonded to the transparent plate, since it is possible to prevent dust from entering between the optical modulation element and the polarizer, the polarization condition of light is not disturbed by dust. Moreover, when a black image is displayed, a spot on the black image corresponding to a portion where dust adheres can be prevented from being displayed as a white blank, and display quality can be improved.

In such a projection display device, the surface of the transparent plate may be coated with a surface active agent or treated for electrostatic protection. In this case, since it is difficult for dust to adhere to the surface of the transparent plate, the adhesion of dust can be avoided more effectively.

BRIEF DESCRIPTION OF THE DRAWINGS
~~Brief Description of the Drawings~~

FIG. 1 is a perspective view showing the external appearance of a projection display device to which the present invention is applied.

FIG. 2 is a schematic plan structural view showing the

internal structure of the projection display device shown in FIG. 1.

FIG. 3 is a schematic sectional structural view taken along line A-A in FIG. 2.

FIG. 4 is a schematic plan structural view showing only an optical unit and a projection lens unit.

FIG. 5 is a schematic structural view of an optical system incorporated in the optical unit.

Figs. 6 (A)-(B) are enlarged view
~~FIG. 6 is an enlarged view~~ showing the surroundings of a liquid crystal modulation element.

FIG. 7 is an exploded perspective view showing the structure of a liquid crystal modulation element unit.

Figs. 8 (A)-(B) are enlarged view
~~FIG. 8 is an enlarged view~~ showing the surroundings of a liquid crystal modulation element in a projection display device according to a second embodiment of the present invention.

FIG. 9 is an enlarged view showing the surroundings of a liquid crystal modulation element in a projection display device according to a third embodiment of the present invention.

FIG. 10 is an enlarged view showing the surroundings of a liquid crystal modulation element in a projection display device according to a fourth embodiment of the present invention.

Figs. 11 (A)-(C) are schematic structural views
~~FIG. 11 is a schematic structural view~~ of an optical

system incorporated in an optical unit of a conventional projection display device.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS
~~Best Mode for Carrying Out the Invention~~

<First Embodiment>

An embodiment of a projection display device, to which the present invention is applied, will described below with reference to the drawings. The projection display device of this embodiment separates a light flux emitted from a light source lamp unit into light fluxes of the primary colors, red (R), blue (B), and green (B), modulates these color light fluxes according to image information through liquid crystal modulation elements serving as optical modulation elements, synthesizes the modulated color light fluxes, and magnifies and displays the synthesized flux onto a screen via a projection lens unit.

FIG. 1 shows the external appearance of the projection display device of this embodiment. As shown in this figure, a projection display device 1 of this embodiment has an outer casing 2 in the shape of a rectangular parallelepiped. The outer casing 2 basically consists of an upper casing 3, a lower casing 4, and a front casing 5 for defining the front of the device. The leading end of a projection lens unit 6 protrudes from the center of the front casing 5.

FIG. 2 shows the layout of components inside the outer

casing 2 of the projection display device 1, and FIG. 3 is a cross-sectional view taken along line A-A in FIG. 2. As shown in these figures, a power supply unit 7 is located on the rear end of the inside of the outer casing 2. A light source lamp unit 8 is placed at a position next to and offset from the power supply unit 7 toward the front side of the device. An optical unit 9 is placed in front of the light source lamp unit 8. Positioned at the front center of the optical unit 9 is the base end of the projection lens unit 6.

On the other hand, an interface substrate 11 with an input-output interface circuit mounted thereon is located on a side of the optical unit 9 so that it extends toward the front and rear of the device, and a video substrate 12 with a video signal processing circuit mounted thereon is located in parallel therewith. Moreover, a control substrate 13 for controlling the drive of the device is placed above the light source lamp unit 8 and the optical unit 9. Speakers 14R and 14L are placed at the right and left front corners of the device, respectively. A suction fan 15A for cooling is placed on the center upper side of the optical unit 9, and a circulating fan 15B for forming a circulating stream for cooling is placed on the center bottom side of the optical unit 9. Furthermore, an exhaust fan 16 is placed on a side of the device, that is, at the rear of the light

source lamp unit 8. Moreover, an auxiliary cooling fan ~~17~~ 30 for sucking the cooling air stream from the suction fan 15A into the power supply unit 7 is placed at a position in the power supply unit 7 opposed to the ends of the substrates 11 and 12.

A floppy-disk drive unit 18 is placed directly above the power supply unit 7 on the left side of the device.

The light source lamp unit 8 includes a light source lamp 80, and a lamp housing 83 having the light source lamp 80 built therein. The light source lamp 80 includes a lamp body 81, such as a halogen lamp, a xenon lamp, or a metal halide lamp, and a reflector 82 provided with a reflecting surface that is parabolic in cross section, and it can reflect light emitted from the lamp body 81 so that the light emerges toward the optical unit 9 almost along the optical axis.

FIG. 4 shows only the optical unit 9 and the projection lens unit 6. In the optical unit 9, as shown in this figure, optical elements other than a color synthesizing prism 910 are vertically sandwiched and held between upper and lower light guides 901 and 902.

These upper and lower light guides 901 and 902 are fixed by fixing screws on the sides of the upper casing 3 and the lower casing 4, respectively. Moreover, the upper and lower light guides 901 and 902 are similarly fixed on

the sides of a color synthesizing prism 910 by fixing screws. The color synthesizing prism 910 is fixed by fixing screws on the rear of a thick head plate 903 formed of a die-cast plate. The base end side of the projection lens unit 6 is similarly fixed on the front of the head plate 903 by fixing screws.

FIG. 5 schematically shows the configuration of an optical system incorporated in the projection display device 1 of this embodiment. The optical system in the projection display device 1 of this embodiment adopts the light source lamp 80 serving as a component of the aforesaid light source lamp unit 8, and a uniform illumination optical system 923 composed of integrator lenses 921 and 922 serving as uniform illumination optical elements.

The projection display device 1 includes a color separation optical system 924 for separating a light flux W emitted from the uniform illumination optical system 923 into red (R), green (G), and blue (B) fluxes, three liquid crystal modulation elements 925R, 925G, and 925B for modulating the respective color light fluxes R, G, and B, the color synthesizing prism 910 serving as a color synthesizing optical system for synthesizing the modulated color light fluxes, and a light guide system 927 for guiding the synthesized color light fluxes to the liquid crystal modulation element 925B corresponding to the blue light flux

B in the projection lens unit 6 that magnifies and projects the synthesized color light fluxes onto the surface of a screen 10.

The uniform illumination optical system 923 includes a reflecting mirror 931 so as to bend an optical axis 1a of light emerging from the light source lamp unit ~~uniform illumination optical system 923~~ into a right angle toward the front of the device. The integrator lenses 921 and 922 intersect at right angles so that the reflecting mirror 931 is located therebetween.

Light emitted from the light source lamp 80 is projected as a secondary light source image via the integrator lens 921 onto the incident surface of each of the lenses that constitute the integrator lens 922. An object to be illuminated is irradiated with the outgoing light from the integrator lens 922.

The color separation optical system 924 includes a blue-green reflecting dichroic mirror 941, a green reflecting dichroic mirror 942, and a reflecting mirror 943. First, the blue light flux B and the green light flux G contained in the light flux W are reflected at right angles by the blue-green reflecting dichroic mirror 941, and directed toward the green reflecting dichroic mirror 942.

The red light flux R passes through the blue-green reflecting mirror 941, is reflected at right angles by the reflecting mirror 943 located behind, and emerges from an

outgoing section 944 for the red light flux R toward the prism unit 910. Next, only the green light flux G of the blue and green light fluxes B and G reflected by the blue-green reflecting mirror 941 is reflected at right angles by the green reflecting dichroic mirror 942, and emerges from an outgoing section 945 for the green light flux G toward the color synthesizing optical system. The blue light flux B having passed through the mirror 942 emerges from an outgoing section 946 for the blue light flux B toward the light guide system 927. In this embodiment, all of the distances between the outgoing section for the light flux W of the uniform illumination optical system ~~optical element~~ and the outgoing sections 944, 945, and 946 for the color light fluxes of the color separation optical system 924 are equally set.

Condenser lenses 951 and 952 are placed on the outgoing sides of the outgoing sections 944 and 945 for the red and green light fluxes R and G in the color separation optical system 942, respectively. Therefore, the red and green light fluxes R and G emerging from the outgoing sections respectively enter the condenser lenses 951 and 952, where they are collimated.

The red and green light fluxes R and G thus collimated enter the liquid crystal modulation elements 925R and 925G, are modulated, and given image information corresponding thereto. That is, these liquid crystal modulation devices ~~light valves~~ 925R and 925G are

subjected to switching control according to image information by a driving means that is not shown, whereby the color light fluxes having passed therethrough are modulated. As such a driving means, well-known means may be used unchanged.

On the other hand, the blue light flux B is guided to the corresponding liquid crystal modulation element 925B via the light guide system 927, where it is similarly modulated according to image information. In the ~~modulation elements~~ liquid crystal modulation devices of this embodiment, for example, a polysilicon TFT may be used as a switching element.

The light guide system 927 includes a condenser lens 954 placed on the outgoing side of the outgoing section 946 for the blue light flux B, an incident-side reflecting mirror 971, an outgoing-side reflecting mirror 972, an intermediate lens 973 interposed between these reflecting mirrors, and a condenser lens 953 placed upstream of the liquid crystal modulation element 925B. The blue light flux B of the color light fluxes has the longest optical path length, that is, the distance between a light source lamp ~~805~~ 80 and the respective liquid crystal panel for the blue light flux B is the longest, and therefore, the amount of light of the blue light flux B to be lost is the largest. The light loss can, however, be restricted by interposing the light guide system 927 therebetween.

The color light fluxes R, G, and B modulated through the respective liquid crystal modulation elements 925R, 925G, and 925B enter the color synthesizing prism 910, where they are synthesized. A color image synthesized by the color synthesizing prism 910 is magnified and projected via the projection lens unit 6 onto the screen 10 located at a predetermined position.

FIG. 6 is an enlarged view showing the surroundings of the liquid crystal modulation elements (optical modulation elements) 925R, 925G, and 925B. As shown in this figure, the color synthesizing prism 910 of this embodiment is in the shape of a quadrangular prism having an almost square cross section by bonding four triangular prisms together. The color synthesizing prism 910 is provided with dielectric multilayer films on the bonded surfaces thereof having the form of an X, and given desired optical properties. The flat liquid crystal modulation elements 925R, 925G, and 925B face three sides (light incident surfaces) 911R, 911G, and 911B of the color synthesizing prism 910 except the side facing the projection lens unit 6 at a predetermined distance. Incident-side polarizers 960R, 960G, and 960B serving as polarizing elements are placed at a predetermined distance from light incident surfaces 9251R, 9251G, and 9251B of the liquid crystal modulation elements 925R, 925G, and 925B, respectively.

On the sides of the liquid crystal modulation elements 925R, 925G, and 925B where light outgoing surfaces 9252R, 9252G, and 9252B are provided, outgoing-side polarizers 961R, 961G, and 961B are bonded to light incident surfaces 911R, 911G, and 911B of the color synthesizing prism 910, respectively. In this embodiment, the outgoing-side polarizers 961R, 961G, and 961B are apart from the light outgoing surfaces 9252R, 9252G, and 9252B of the liquid crystal modulation elements 925R, 925G, and 925B.

Bonded to the light outgoing surfaces 9252R, 9252G, and 9252B of the liquid crystal modulation elements 925R, 925G, and 925B are transparent plates 970R, 970G, and 970B that are made of the same material as that of the substrates (not shown) for sandwiching a polarizing layer of the members constituting the outgoing-side polarizers 961R, 961G, and 961B, such as for example, triacetate cellulose.

The optical axes of the transparent plates 970R, 970G, and 970B almost align with the optical axes of the outgoing-side polarizers 961R, 961G, and 961B. Moreover, antireflection thin films are formed on the outgoing-side surfaces of the transparent plates 970R, 970G, and 970B by evaporation. The antireflection films prevent light reflection at the interface surfaces between the liquid crystal modulation elements 925R, 925G, and 925B and air because of the difference in refractive index therebetween,

thereby eliminating return light to the liquid crystal modulation elements 925R, 925G, and 925B, and preventing the malfunction of the liquid crystal modulation elements 925R, 925G, and 925B.

FIG. 7 shows a structure in which such liquid crystal modulation elements 925R, 925G, and 925B are attached to the light incident surfaces of the color synthesizing prism 910.

In FIG. 7, a mounting member 70R is shown in a disassembled state.

The mounting member 70R includes a mounting frame plate 71 for holding the liquid crystal modulation element 925R and the transparent plate 970R. The mounting frame plate 71 includes first and second frame plates 72 and 73 between which the liquid crystal modulation element 925R and the transparent plate 970R are sandwiched and held. FIG. 7 shows only the first frame plate 72, and the second frame plate 73, the liquid crystal modulation element 925R, and the transparent plate 970R having already been fixed to the first frame plate 72. The mounting member 70R also includes a fixed frame plate 74 to be fixedly bonded to the light incident surface 911R of the color synthesizing prism 910. The mounting frame plate 71 is detachably fixed to the fixed frame plate 74 via an intermediate frame plate 75.

The first frame plate 72 of the mounting frame plate 71 has a rectangular opening 72a for light transmission, and a

peripheral wall 72b having a uniform thickness on the periphery thereof. The second frame plate 73 also has a rectangular opening (not shown) for light transmission. The size of the second frame plate 73 is such that it just fits in the inside of the peripheral wall 72b of the first frame plate 72.

Therefore, by fitting the second frame plate 73 in the first frame plate 72 while the liquid crystal modulation element 925R and the transparent plate 970R are sandwiched therebetween, the mounting frame plate 71 is formed, in which the liquid crystal modulation element 925R and the transparent plate 970R are held between these frame plates 72 and 73.

The intermediate frame plate 75 is a rectangular frame that has almost the same size as that of the first frame plate 72 of the mounting frame plate 71, and is provided with a rectangular opening 75a for light transmission. The intermediate frame plate 75 has engaging projections 75d that extend perpendicularly from the surface of the frame plate at the four corners of the rectangular opening 75a. The first frame plate 72 of the mounting frame plate 71 has engaging holes 72d formed at positions corresponding to the respective engaging projections 75d, into which the engaging projections 75d can be inserted. Therefore, when the respective engaging holes 72d of the mounting frame plate 71

and the engaging projections ~~75b~~ 75d of the intermediate frame plate 75 are aligned and overlaid one on another , the respective engaging projections 75d are inserted in the respective engaging holes 72d, whereby a temporarily attached state is obtained.

On the other hand, the fixed frame plate 74 is also a rectangular frame plate having a rectangular opening 74a for light transmission. The rear of the fixed frame plate 74 is fixed on the light incident surface 911R of the color synthesizing prism 910 with an adhesive. The fixed frame plate 74 has screw holes 74c at both ends of its upper frame section and at the widthwise center of its lower frame section. The intermediate frame plate 75 also has screw holes 75c corresponding to the three screw holes 74c, and is fixed to the fixed frame plate 74 by inserting flat-head screws 76 for fastening into the corresponding screw holes 74c and 75c. While the intermediate frame plate 75 is fixed to the fixed frame plate 74 by the three screws 76 in this embodiment, the number of screws may be four ~~as shown in FIG. 5~~, or more. In general, as the number of screws decreases, the number of steps of fastening the screws decreases.

The fixed frame plate 74 also has engaging projections 74b at the right and left corners of its lower frame section. Corresponding to the two engaging projections 74b,

the intermediate frame plate 75 has engaging holes 75b at the right and left corners of its lower frame section. Therefore, when being fixed with the screws 76, the intermediate frame plate 75 can be temporarily fixed to the fixed frame plate 74 by pushing the intermediate frame plate 75 toward the fixed frame plate 74 while aligning the engaging holes 75b of the intermediate frame plate 75 with the engaging projections 74b of the fixed frame plate 74. This makes it possible to further improve the positioning accuracy of both the frame plates.

a Such a liquid crystal modulation device mounting member ~~modulation element unit~~ 70R includes positioning means for positioning the mounting frame plate 71 with respect to the intermediate frame plate 75 that is fixed to the fixed frame plate 74. The positioning means includes two wedges 77. Wedge guide surfaces 72e to 72g, against which inclined surfaces 77a of the wedges 77 abut, are formed on the vertical centers of the right and left sides of the peripheral wall 72a of the first frame plate 72 in the mounting frame plate 71. When the mounting frame plate 71 is temporarily attached to the intermediate frame plate 75, wedge insertion grooves are formed between the wedge guide surfaces 72e of the first frame plate 72 and the frame sections of the intermediate frame plate 75 facing the wedge guide surfaces 72e.

Therefore, after the mounting frame plate 71 is

temporarily attached to the intermediate frame plate 75, the two wedges 77 are driven in the right and left sides of the first frame plate 72, and the amount of the wedges 77 to be driven in is adjusted, whereby the liquid crystal modulation device 925R ~~liquid crystal panel 40R~~ can be positioned.

In this embodiment, the fixed frame plate 74 and the intermediate frame plate 75 are flat. As mentioned with reference to FIG. 3, the circulating fan 15B is placed below the color synthesizing prism 910, and cooling air flows from bottom to top. In order to prevent this flow from being disturbed, it is preferable to place straightening vanes above the circulating fan 15B. Since the fixed frame plate 74 and the intermediate frame plate 75 are flat, the straightening vanes can be mounted at a position directly below the mounting member 70R. Consequently, cooling air can flow effectively from bottom to top. Furthermore, since these frame plates have a simple shape, parts can be easily utilized, and the accuracy of the parts is thereby improved.

Furthermore, in the mounting member 70R ~~70~~, the two wedges 77 are used for positioning, and they are fixedly bonded to the vertical centers of the right and left sides of the first frame plate 72 and the intermediate frame plate 75. If the wedges 77 are fixedly bonded at inadequate positions, there is a fear that heat deformation of the first frame plate 72, the intermediate frame plate 75, or the wedges 77

will cause excessive stress concentration in the respective members. Moreover, this may cause the wedges 77 to separate from the first frame plate 72 or the intermediate frame plate 75.

As mentioned above, however, since the wedges 77 are fixedly bonded to the centers of the right and left sides, the first frame plate 72 and the intermediate frame plate 75 are free to thermally deform in the vertical direction centered on the wedges 77. Therefore, the degree to which the heat deformation of these frame plates is restrained is low, and it is possible to avoid negative effects, such as undesired stress concentration and separation of the wedges.

Furthermore, each of the wedges 77 of this embodiment each has two blind holes 77c on its rear side 77b, as shown in FIG. 7. In chucking the wedges 77 with a jig, these blind holes 77c function as engaging portions for chucking. Such blind holes 77c permit easy chucking and easy handling.

While the blind holes 77c for engagement in chucking are formed on the rear side of the wedges 77 in this embodiment, such engaging portions for chucking may be formed in other members. For example, engaging portions for chucking, such as blind holes, may be formed on the outer surface of the peripheral wall ~~72a~~ 72b of the panel frame plate 71.

In this case, when the mounting frame plate 71 is made

of a resin containing glass fiber, such as FRP, it is possible to restrict linear expansion, to prevent the shift of the liquid crystal modulation elements 925R, 925G, and 925B, and to maintain a constant temperature and a uniform in-plane temperature distribution of the liquid crystal modulation elements 925R, 925G, and 925B.

Furthermore, when the mounting frame plate 71 is made of metal, it is possible to improve the heat radiation effect. This is effective, in particular, when a polarizer is bonded to the transparent plate because the heat caused by light being absorbed by the polarizer can be efficiently radiated.

In the projection display device 1 of this embodiment that has such a construction, since the outgoing-side polarizers 961R, 961G, and 961B are apart from the light outgoing surfaces 9252R, 9252G, and 9252B of the liquid crystal modulation elements 925R, 925G, and 925B, the heat generated by the outgoing-side polarizers 961R, 961G, and 961B can be prevented from being transmitted to the liquid crystal modulation elements 925R, 925G, and 925B. This makes it possible to limit the increase in temperature of the liquid crystal modulation elements 925R, 925G, and 925B, and to prevent the deterioration of the optical properties thereof.

Furthermore, since the liquid crystal modulation

elements 925R, 925G, and 925B and the outgoing-side polarizers 961R, 961G, and 961B are apart from each other, the light emitted from the liquid crystal modulation elements 925R, 925G, and 925B widely spread, and the polarizers 961R, 961G, and 961B can receive the light in a wide area. As a result, it is possible to decrease the heat generated by the polarizers 961R, 961G, and 961B per unit area, and to permit easy heat radiation. In particular, it is effective to place a microlens array, which gathers light onto each pixel of the light valve, on the light incident side of each of the liquid crystal modulation elements 925R, 925G, and 925B because the light can spread more widely.

Inside the projection display device 1 of this embodiment, an air flow is formed as shown by the arrow in FIG. 6(B). Accordingly, if the light outgoing surfaces 9252R, 9252G, and 9252B of the liquid crystal modulation elements 925R, 925G, and 925B are exposed, they are soiled by the dust that is diffused by the air flow and adheres thereto. In the projection display device 1 of this embodiment, however, since the transparent plates 970R, 970G, and 970B are bonded to the light outgoing surfaces 9252R, 9252G, and 9252B of the liquid crystal modulation elements 925R, and 925G, and 925B, the negative effects mentioned above can be avoided.

It is preferable to set the thickness of the

transparent plates 970R, 970G, and 970B sufficiently large with respect to the focal depth of the projection lens. This is because dust or the like is thereby blurred and made inconspicuous even when it adheres to the surface of the transparent plates 970R, 970G, or 970B.

Furthermore, since the optical axes of the transparent plates 970R, 970G, and 970B almost align with those of the outgoing-side polarizers 961R, 961G, and 961B in the projection display device 1 of this embodiment, it is possible to prevent image degradation resulting from the anisotropy that the liquid crystal modulation elements 925R, 925G, and 925B possess.

Still furthermore, since the transparent plates 970R, 970G, and 970B are made of the same material as that of the substrates for sandwiching the polarizing layer of the polarizers 961R, 961G, and 961B, the number of types of components can be reduced. Moreover, since the substrates for sandwiching the polarizing layer are bonded to the liquid crystal modulation element, they cause few defects. Therefore, image degradation due to the defects of the transparent plate can be naturally prevented by making the transparent plate of the same material as that of the substrates for sandwiching the polarizing layer.

Yet furthermore, the transparent plates 970R, 970G, and 970B mentioned above may be formed on the light incident

surfaces of the liquid crystal modulation elements 925R, 925G, and 925B. In this case, even if dust or the like adheres to the light incident surface of the liquid crystal modulation element, it is inconspicuous on the screen. Moreover, the transparent plates 970R, 970G, and 970B may be formed on both the light incident and outgoing surfaces of the liquid crystal modulation elements 925R, 925G, and 925B.

Yet still furthermore, the surfaces of such transparent plates 970R, 970G, and 970B may be coated with a surface active agent(interfacial active agent), or treated for electrostatic protection. Since this makes it difficult for dust to adhere to the surfaces of the transparent plates 970R, 970G, and 970B, the adhesion of dust can be prevented more effectively.

In addition, polarizers 961R, 961G, and 961B may be bonded to the transparent plates 970R, 970G, and 970B. In this case, it is possible to prevent dust from entering between the liquid crystal modulation elements 925R, 925G, and 925B and the polarizers 961R, 961G, and 961B, and to thereby prevent the polarization condition of light from being disturbed by dust. Moreover, when a black image is displayed, its portion corresponding to the adhering dust can be prevented from being displayed as a white blank, and display quality can be improved.

The polarizers include two types of polarizers, a

reflective polarizer and an absorptive polarizer. The reflective polarizer transmits one of two types of linearly polarized light fluxes, and reflects the other linearly polarized light flux. The absorptive polarizer transmits one of two types of linearly polarized light fluxes, and absorbs the other linearly polarized light flux. The polarizers 960R, 960G, 960B, 961R, 961G, and 961B may be either reflective or absorptive ~~transmissive~~.

The outgoing-side polarizers 961R, 961G, and 961B may be independently placed between the liquid crystal modulation elements 925R, 925G, and 925B and the color synchronizing prism 910 without being bonded to the color synthesizing prism 910.

<Second Embodiment>

FIG. 8 schematically shows the construction of the surroundings of liquid crystal modulation elements in a projection display device according to a second embodiment of the present invention. Since the projection display device of this embodiment has a similar construction to that of the projection display device 1 except that the surroundings of the liquid crystal modulation elements are different, a description will only be given of different points. In FIG. 8, the components common to those of the projection display device 1 are denoted by the same numerals, and the description thereof is omitted.

As shown in FIG. 8, in the projection display device of this embodiment, three liquid crystal modulation elements 925R, 925G, and 925B and a color synthesizing prism 910 are completely enclosed by a partition 983 that tightly surrounds the liquid crystal modulation elements 925R, 925G, and 925B via air. Inside the partition 983, a fan 987 is located to circulate air. In this embodiment, an air flow 985 is formed inside the partition 983 by the fan 987, as shown by the arrows in FIGS. 8(A) and 8(B) ~~FIGS. 12(A) and 12(B)~~.

The partition 983 has light incident windows at the positions opposing light incident surfaces 9251R, 9251G, and 9251B of the three liquid crystal modulation elements 925R, 925G, and 925B. The light incident windows are provided with transparent plates 980R, 980G, and 980B made of glass or the like. Moreover, the partition 983 also has a light outgoing window 990 formed of an opening that faces the light outgoing surfaces of the color synthesizing prism 910. Therefore, respective color light fluxes R, G, and B pass through the transparent plates 980R, 980G, and 980B, and enter the corresponding liquid crystal modulation elements 925R, 925G, and 925B. The color light fluxes R, G, and B are modulated by the liquid crystal modulation elements 925R, 925G, and 925B, synthesized by the color synthesizing prism 910, and then, emerge from the light outgoing window 990 toward the projection lens unit 6.

Incident-side polarizers 960R, 960G, and 960B are bonded to the outsides of the transparent plates 980R, 980G, and 980B, and a common outgoing-side polarizer 982 is fitted in the light outgoing window 990. That is, the outgoing-side polarizer 982 is positioned apart from light outgoing surfaces 9252R, 9252G, and 9252B of the liquid crystal modulation elements 925R, 925G, and 925B.

In the projection display device of this embodiment that has the above-mentioned construction, the heat generated by the liquid crystal modulation elements 925R, 925G, and 925B is absorbed by the partition 983 by means of the air flow 985 formed by the fan 987, and then, is radiated to the outside from the partition 983. The heat radiated from the partition 983 and the heat generated by the incident-side polarizers 960R, 960G, and 960B, and the outgoing-side polarizer 982 are removed by an air flow formed inside the device by the suction fan 15A and the exhaust fan 16 shown in FIGS. 2 and 3.

Therefore, it is possible to limit the increase in temperature of the liquid crystal modulation elements 925R, 925G, and 925B and the incident- and outgoing-side polarizers 960R, 960G, 960B, and 982, and to prevent deterioration of the optical properties. Moreover, since the liquid crystal modulation elements 925R, 925G, and 925B are completely enclosed by the partition 983, dust, fuzz or

the like does not enter the inside of the partition 983 from the outside. This makes it possible to prevent image degradation caused by, for example, dust or the like projected on the screen that gives an unsightly appearance. As the material of the partition 983, it is preferable to use a metal having a high heat absorbency, such as magnesium or aluminum.

Furthermore, since the liquid crystal modulation elements 925R, 925G, and 925B and the outgoing-side polarizer 982 are apart from each other, the light emitted from the liquid crystal modulation elements 925R, 925G, and 925B widely spread, and the polarizer 982 can receive the light in a wide area. As a result, it is possible to decrease the heat generated by the polarizer 982 per unit area, and to permit easy heat radiation. In particular, it is effective to place a microlens array, which gathers light onto each pixel of the light valve, on the light incident side of each of the liquid crystal modulation elements 925R, 925G, and 925B because the light can spread more widely.

Such transparent plates 980R, 980G, and 980B may be coated with a surface active agent(interfacial active agent), or treated for electrostatic protection. In this case, since it is difficult for dust to adhere thereto, it is possible to prevent the dust adhesion more effectively.

The polarizers include two types of polarizers, a

reflective polarizer and an absorptive polarizer. The reflective polarizer transmits one of two types of linearly polarized light fluxes, and reflects the other linearly polarized light flux. The absorptive polarizer transmits one of two types of linearly polarized light fluxes, and absorbs the other linearly polarized light flux. The polarizers 960R, 960G, 960B, and 982 may be either reflective or transmissive.

<Third Embodiment>

While the projection display devices using transmissive liquid crystal modulation elements as the liquid crystal modulation elements have been described in the first and second embodiments, the present invention can be applied to a projection display device that uses a reflective liquid crystal modulation element as the liquid crystal modulation element. An example of a projection display device using a reflective liquid crystal modulation element will be described below.

FIG. 9 is a schematic structural view showing the surroundings of light valves in the projection display device of this embodiment. In FIG. 9, a polarization beam splitter 1900 is formed of a prism having an s-polarized light flux reflecting plane 1901 that reflects an s-polarized light flux and transmits a p-polarized light flux. The polarization beam splitter 1900 bends an s-polarized

light component of illumination light, which is emitted from the light source lamp unit 8, into an angle of 90° by the s-polarized light flux reflecting plane 1901, and causes the s-polarized light component to enter a dichroic prism 1910 that functions as color separation means and color synthesizing means.

The dichroic prism 1910 includes dichroic films bonded in the form of an X, and separates incident illumination light into three color light fluxes R, G, and B. The respective color light fluxes separated by the dichroic prism 1910 enter light incident and outgoing surfaces of reflective liquid crystal modulation elements 1925R, 1925G, and 1925B that are placed along three sides of the dichroic prism 1910. The respective color light fluxes incident on the reflective liquid crystal modulation elements 1925R, 1925G, and 1925B are modulated therein, and emitted from the same light incident and outgoing surfaces to the dichroic prism 1910.

The reflective liquid crystal modulation elements 1925R, 1925G, and 1925B of this embodiment are of the super homeotropic alignment type in which liquid crystal molecules vertically align when voltage is not applied (off), and they are twisted through 90° when voltage is applied (on). Accordingly, the s-polarized light fluxes incident on the reflective liquid crystal modulation elements 1925R, 1925G,

and 1925B when voltage is not applied (off) are returned to the dichroic prism 1910 without changing their polarization direction.

On the other hand, the s-polarized light fluxes incident on the reflective liquid crystal modulation elements 1925R, 1925G, and 1925B when voltage is applied (on) are turned into p-polarized light fluxes with their polarization direction changed by the twisting of the liquid crystal molecules, and then, returned to the dichroic prism 1910.

The light fluxes modulated by the reflective liquid crystal modulation elements 1925R, 1925G, and 1925B are synthesized by the dichroic prism 1910, and projected onto a projection plane (screen) via the polarization beam splitter 1900, a polarizer 1920, and the projection lens unit 6.

In the projection display device using such reflective liquid crystal modulation elements 1925R, 1925G, and 1925B, transparent plates 1970R, 1970G, and 1970B, which are similar to those mentioned in the first embodiment, are bonded to the light incident and outgoing surfaces of the reflective liquid crystal modulation elements 1925R, 1925G, and 1925B, respectively. Therefore, it is possible to prevent the light reflection at the interfaces between the light incident and outgoing surfaces of the reflective liquid crystal modulation elements 1925R, 1925G, and 1925B

and air because of the difference in refractive index therebetween. This can improve the light utilizing efficiency.

Even if dust or the like is diffused by an air flow formed inside the device, dust is prevented by the transparent plates 1970R, 1970G, and 1970B from directly adhering to the light incident and outgoing surfaces of the reflective liquid crystal modulation elements 1925R, 1925G, and 1925B. Therefore, in the projection display device of this embodiment that uses the reflective liquid crystal modulation elements 1925R, 1925G, and 1925B as the liquid crystal modulation elements, high-quality image projection can be achieved by preventing dust from adhering to the light incident and outgoing surfaces of the liquid crystal modulation elements 1925R, 1925G, and 1925B without deteriorating the switching characteristic of the liquid crystal modulation elements 1925R, 1925G, and 1925B.

The surfaces of such transparent plates 1970R, 1970G, and 1970B may be coated with a surface active agent(interfacial active agent), or treated for electrostatic protection. Since this makes it difficult for dust to adhere to the surfaces of the transparent plates 1970R, 1970G, and 1970B, the adhesion of dust can be prevented more effectively.

The polarizer 1920 placed between the polarization beam

splitter 1900 and the projection lens unit 6 operates to improve the contrast of a projected image. Therefore, this polarizer 1920 may be omitted in a case in which a projected image is not required to have high contrast.

The polarizers include two types of polarizers, a reflective polarizer and an absorptive polarizer. The reflective polarizer transmits one of two types of linearly polarized light fluxes, and reflects the other linearly polarized light flux. The absorptive polarizer transmits one of two types of linearly polarized light fluxes, and absorbs the other linearly polarized light flux. The polarizer 1920 may be either reflective or absorptive ~~transmissive~~.

While the transparent plates 1970R, 1970G, 1970B are bonded to the light incident and outgoing surfaces of the reflective liquid crystal modulation elements 1925R, 1925G, and 1925B in the above embodiment, the reflective liquid crystal modulation elements 1925R, 1925G, and 1925B and the dichroic prism 1910 may be enclosed by a partition as described in the second ~~third~~ embodiment.

<Fourth Embodiment>

Next, a description will be given of another example of a projection display device that adopts reflective liquid crystal modulation elements.

FIG. 10 is a schematic structural view showing the surroundings of light valves in the projection display

device of this embodiment. In FIG. 10, the projection display device includes a blue reflecting dichroic mirror 2941 and a red-green reflecting dichroic mirror 2942 that reflect illumination light emitted from the light source lamp unit 8. A blue light flux B contained in a light flux W is reflected at right angles by the blue reflecting dichroic mirror 2941, is further reflected at right angles by a reflecting mirror 2971, and enters a first polarization beam splitter 2900B located next to a dichroic prism 2910.

This polarization beam splitter 2900B is formed of a prism having an s-polarized light flux reflecting plane 2901B that is made of a polarized light separation film for reflecting an s-polarized light flux and transmitting a p-polarized light flux. The polarization beam splitter 2900B bends an s-polarized light component of the blue light flux into 90° by the s-polarized light flux reflecting plane 2901B, and causes the s-polarized light component to enter a light incident and outgoing surface of a reflective liquid crystal modulation element 2925B that is located opposing one side of the polarization beam splitter 2900B and provided with a transparent plate 2970B on the light incident and outgoing surface. Then, only a p-polarized light of the blue light flux, which is modulated by the liquid crystal modulation element 2925B and transmitted through the s-polarized light flux reflecting plane 2901B,

emerges from the same light incident and outgoing surfaces to the dichroic prism 2910.

On the other hand, a red light flux R and a green light flux G are first reflected at right angles by the red-green reflecting dichroic mirror 2942, and further reflected at right angles by a reflecting mirror 2972.

After passing through a green reflecting dichroic mirror ~~2941~~ 2943, the red light flux R enters a second polarization beam splitter 2900R that is located on an opposite side to the first polarization beam splitter 2900B across the dichroic prism 2910. The second polarization beam splitter 2900R is formed of a prism having an s-polarized light flux reflecting plane ~~2901B~~ 2901R that is made of a polarized light separation film for reflecting an s-polarized light flux and transmitting a p-polarized light flux.

The second polarization beam splitter 2900R bends the s-polarized light component of the red light flux into 90° by the s-polarized light flux reflecting plane 2901R, and causes the s-polarized light component to enter a light incident and outgoing surface of a reflective liquid crystal modulation element 2925R that is located opposing one side of the polarization beam splitter 2900R and provided with a transparent plate 2970R on the light incident and outgoing surface. Only p-polarized light of the red light flux,

which is modulated by the liquid crystal modulation element 2925R and transmitted through the s-polarized light flux reflecting plane 2901R, emerges from the same light incident and outgoing surface to the dichroic prism 2910.

After being reflected by the green reflecting dichroic mirror 2943, the green light flux G enters a third polarization beam splitter 2900G located on one side of the dichroic prism 2910. The third polarization beam splitter 2900G is formed of a prism having an s-polarized light flux reflecting plane 2901G made of a polarized light separation film that reflects an s-polarized light flux and transmits a p-polarized light flux. This polarization beam splitter 2900G bends an s-polarized light component of the green light flux G into 90° by the s-polarized light flux reflecting plane 2901G, and causes the s-polarized light component to enter a light incident and outgoing surface of a reflective liquid crystal modulation element 2925G that is located opposing one side of the polarization beam splitter 2900G and provided with a transparent plate 2970G on the light incident and outgoing surfaces.

Then, only p-polarized light of the green light flux, which is modulated by the liquid crystal modulation element 2925G and transmitted through the s-polarized light flux reflecting plane 2901G, emerges from the same light incident and outgoing surfaces to the dichroic prism 2910.

As mentioned above, the respective light fluxes B, G, and R modulated through the liquid crystal modulation elements 2925B, 2925R, and 2925G enter the dichroic prism 2910, where they are synthesized. The synthesized color image is magnified and projected via the projection lens unit 6 onto a screen ~~10~~ that is placed at a predetermined position.

In the projection display device using such reflective liquid crystal modulation elements 2925R, 2925G, and 2925B, the transparent plates 2970R, 2970G, and 2970B, which are similar to the transparent plates mentioned in the above first embodiment, are bonded to the light incident and outgoing surfaces of the reflective liquid crystal modulation elements 2925R, 2925G, and 2925B, respectively. Therefore, it is possible to prevent the light reflection at the interfaces between the light incident and outgoing surfaces of the reflective liquid crystal modulation elements 2925R, 2925G, and 2925B and air because of the difference in refractive index therebetween, and to thereby improve the light utilizing efficiency.

Even if dust or the like is diffused by an air flow formed inside the device, dust is prevented by the transparent plates 2970R, 2970G, and 2970B from directly adhering to the light incident and outgoing surfaces of the reflective liquid crystal modulation elements 2925R, 2925G,

and 2925B. Therefore, in the projection display device of this embodiment that uses the reflective liquid crystal modulation elements 2925R, 2925G, and 2925B as the liquid crystal modulation elements, the switching characteristic of the reflective liquid crystal modulation elements 2925R, 2925G, and 2925B is not deteriorated, and the dust is prevented from adhering to the light incident and outgoing surfaces of the reflective liquid crystal modulation elements 2925R, 2925G, and 2925B, whereby a high-quality image can be projected.

The surfaces of such transparent plates 2970R, 2970G, and 2970B may be coated with a surface active agent(interfacial active agent), or treated for electrostatic protection. Since this makes it difficult for dust to adhere to the surfaces of the transparent plates 2970R, 2970G, and 2970B, the adhesion of dust can be prevented more effectively.

While the transparent plates 2970R, 2970G, and 2970B are bonded to the light incident and outgoing surfaces of the reflective liquid crystal modulation elements 2925R, 2925G, and 2925B in the above embodiment, the reflective liquid crystal modulation elements 2925R, 2925G, and 2925B and the dichroic prism 2910 may be enclosed by a partition as mentioned in the third embodiment.

<Other Embodiments>

While the projection display device having three liquid crystal modulation elements for modulating three colored lights, respectively, is described in the above first embodiment, a projection display device to which the present invention applies is not limited to the above-mentioned device, for example, it may use only a single liquid crystal modulation element. Moreover, the projection display devices are divided into two types, a front type that performs projection from the side on which the screen is viewed, and a rear type that performs projection from the side opposite to the screen viewing side, and the present invention is applicable to either of the types.

Industrial Applicability

The present invention can be used as a projection display device that optically processes a light flux emitted from a light source and magnifies and projects an image onto a projection plane, such as a video projector having liquid crystal modulation elements.